Chilled Water
Energy Savings Study
Maximizing Pumping and Chiller Efficiency.

2014 AHR Expo Innovation Award" Winner in the Category of Building Automation

The Belimo Energy Valve™ won the "Technical Innovation of the Year – Products" at the BCIA Building Controls Industry Association Awards.

Chilled Water Energy Savings Study

- Pressure Dependent Valve Sizing and Valve Authority
- Pressure Independent Valves (Mechanical and Electronic)
- Chilled Water System Design
- MIT Beta Site Study-Correcting Low delta T
- Calculate savings

Pressure Dependent Valve Sizing and Operation

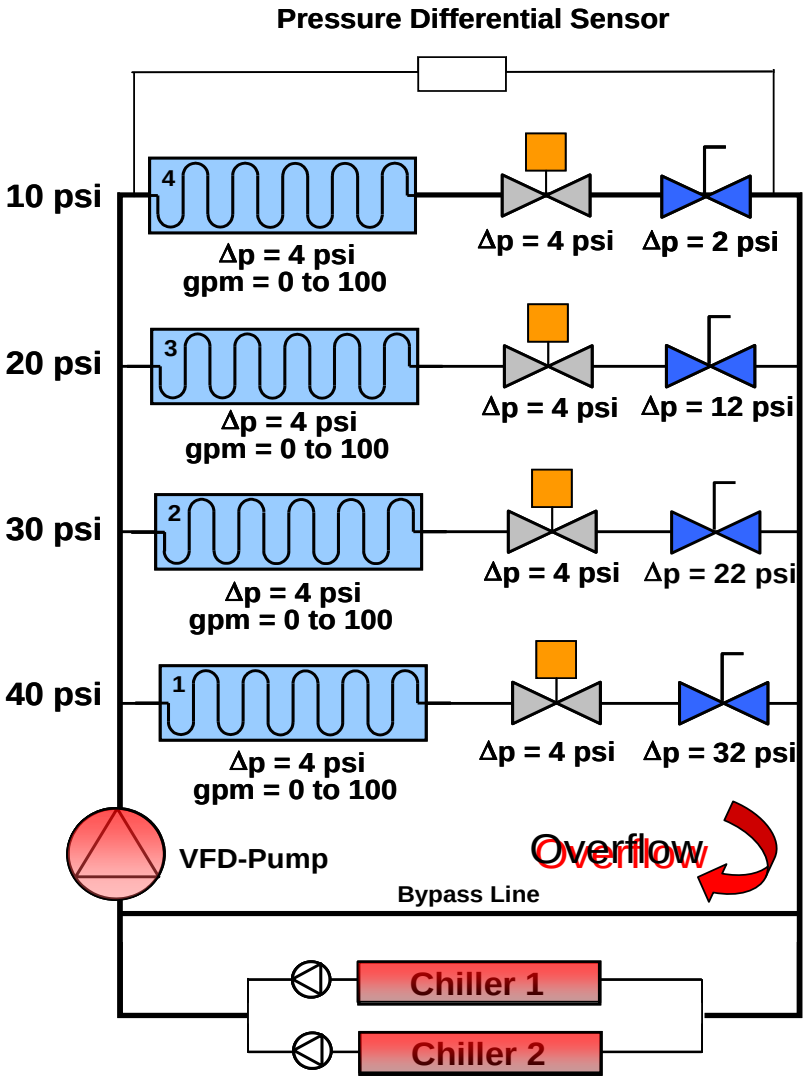
Pressure Dependent Flow Coefficient-Valve Sizing

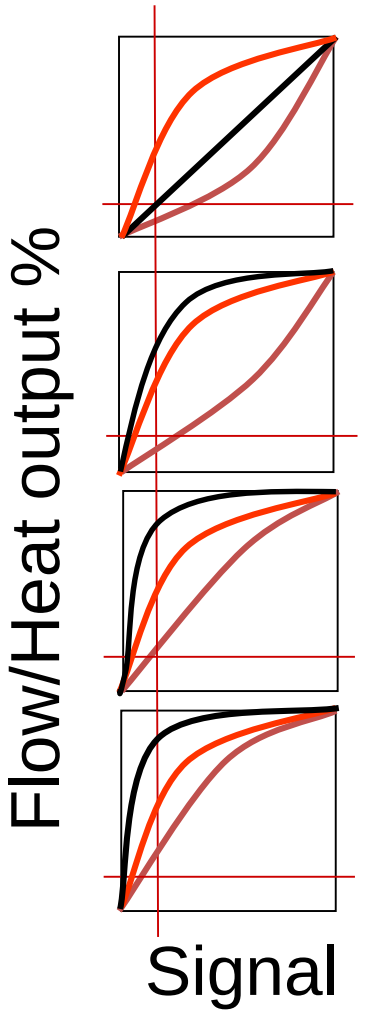
$$Cv = \frac{GPM}{\sqrt{\Delta P}}$$

- **1 Cv = 1 gallon of 60 DegF water passing through a fully open control valve with a pressure drop of 1 psi.**
- **Sizing is typically done using a PD of 3-5 PSI**
- **Manual balancing can not maintain a constant PD and causes overflow and low delta T.**

when the pressure drop increases the flow increases

Pressure Dependent Valve Authority
Should =.4 or greater





A=4/10=0.40

A=4/20=0.20

A=4/30=0.13

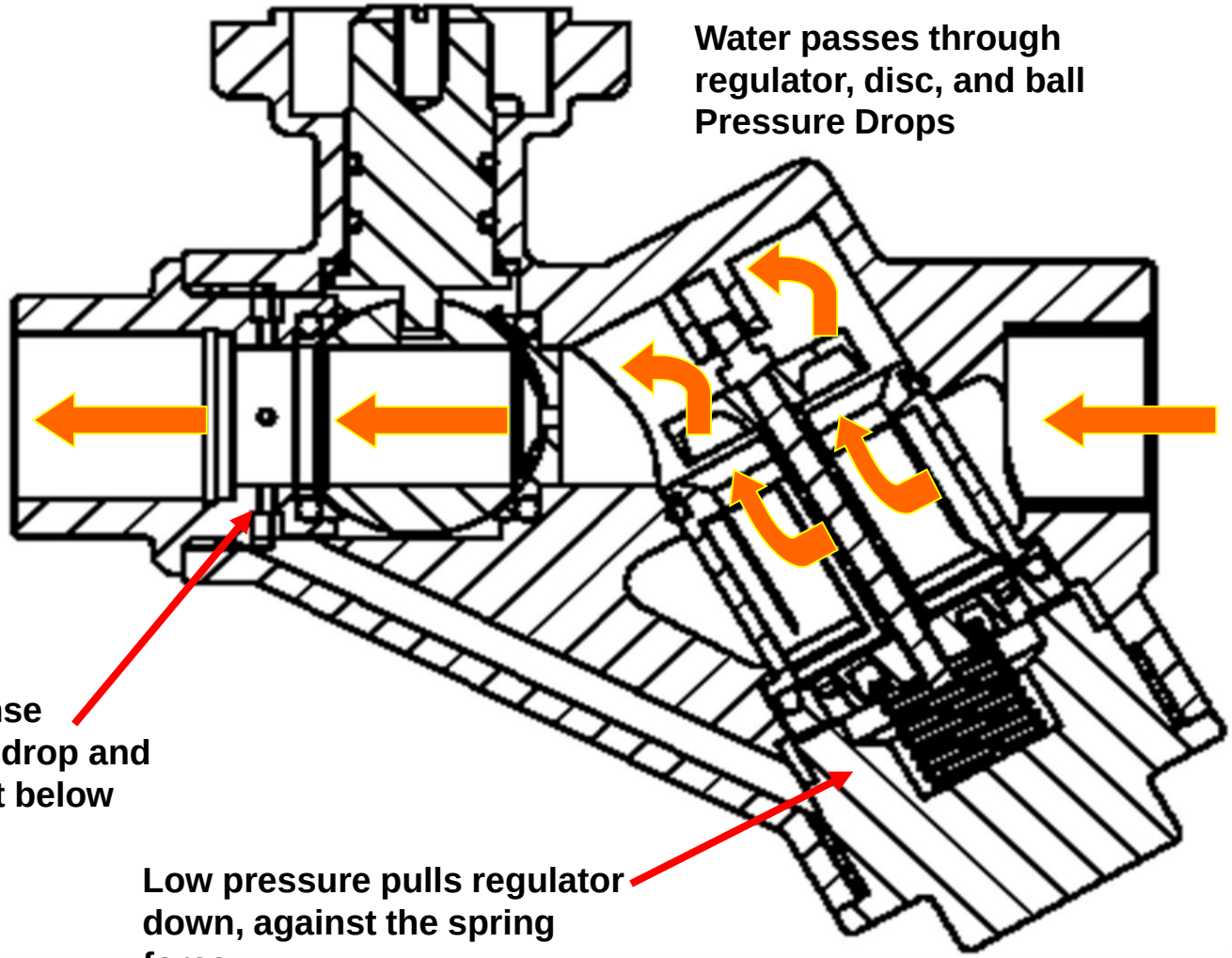
A=4/40=0.10

Accumulative Waste

Pressure Independent Control Valve

Mechanically Regulated

Operational theory-VENTURI = DYNAMIC BALANCING
Replaces control valve and balance valve



Water passes through regulator, disc, and ball Pressure Drops

Water exits valve

Pressure is P2 (low)

Water enters valve

Pressure is P1 (high)

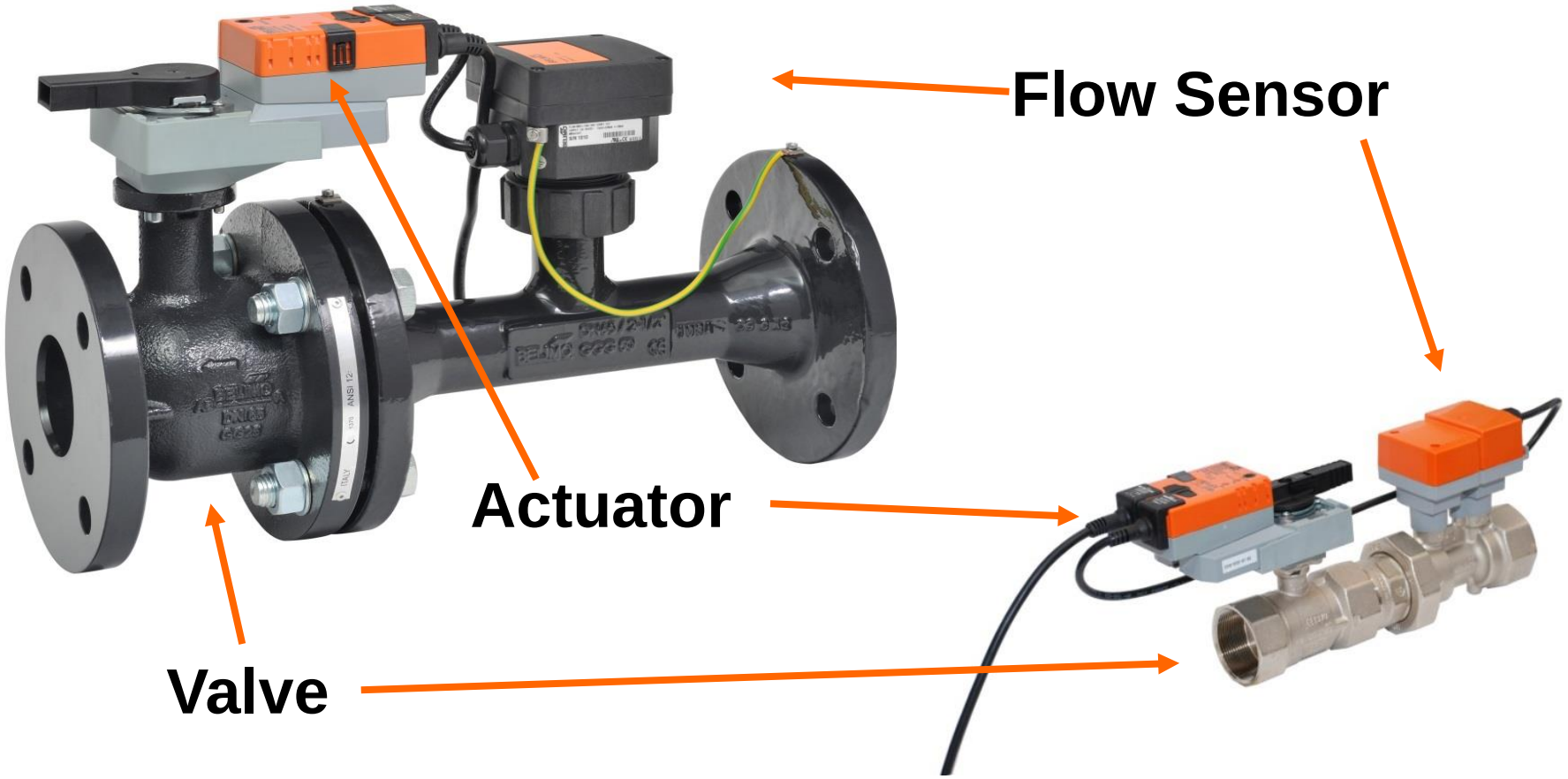
Ports sense pressure drop and transfer it below regulator

Low pressure pulls regulator down, against the spring force

Electronic Pressure Independent Valve

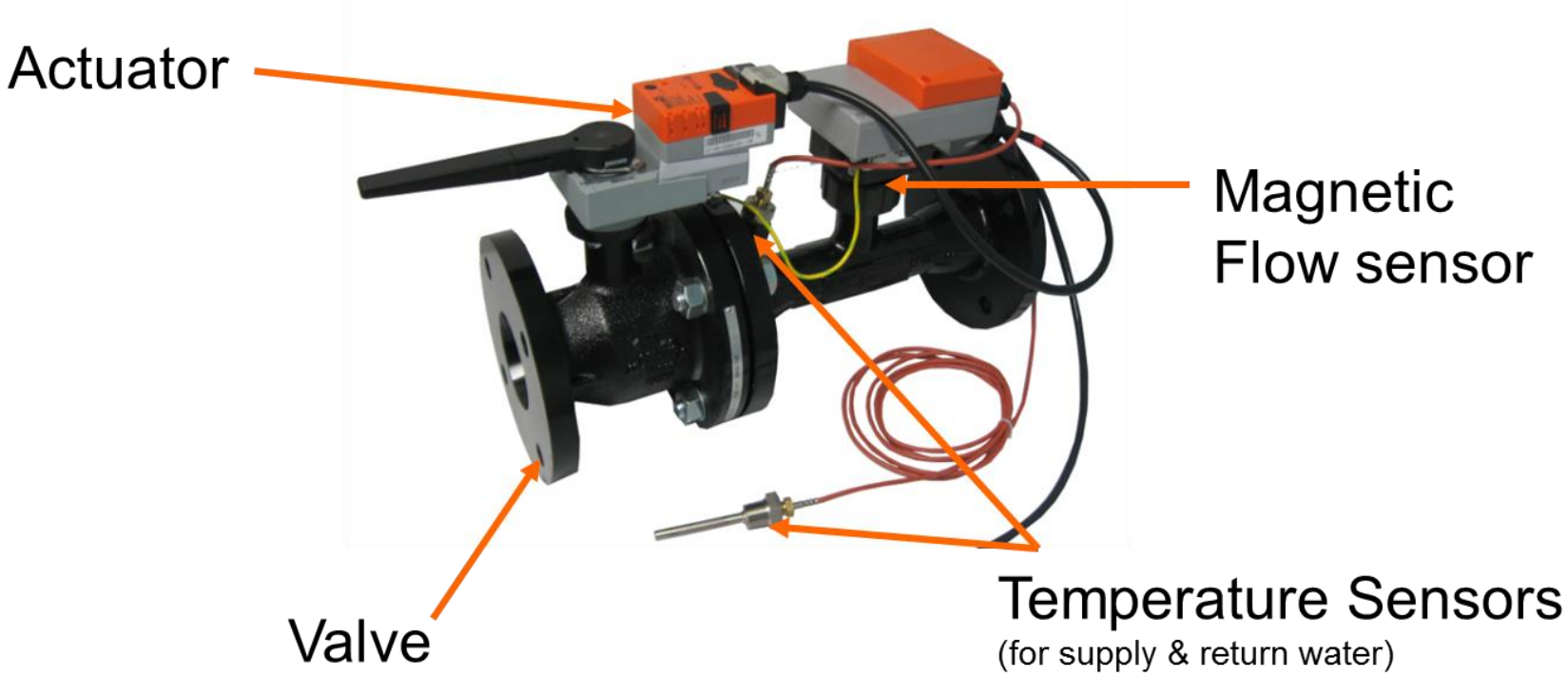
Flow Meter (True Flow) Regulating

1/2”– 6”, 1.65 thru 713 GPM



Electronic Pressure Independent Valve

Delta T Management and BTU Meter



Typical Chilled Water Design

Flow and delta T are inversely proportional. For a given load, when delta T drops flow has to increase to satisfy the load.

$$GPM = \frac{Tons \times 24}{\Delta T}$$

$$800\,GPM = \frac{Tons \times 24}{12° \Delta T}$$

$$800\,GPM = Tons \times 2$$

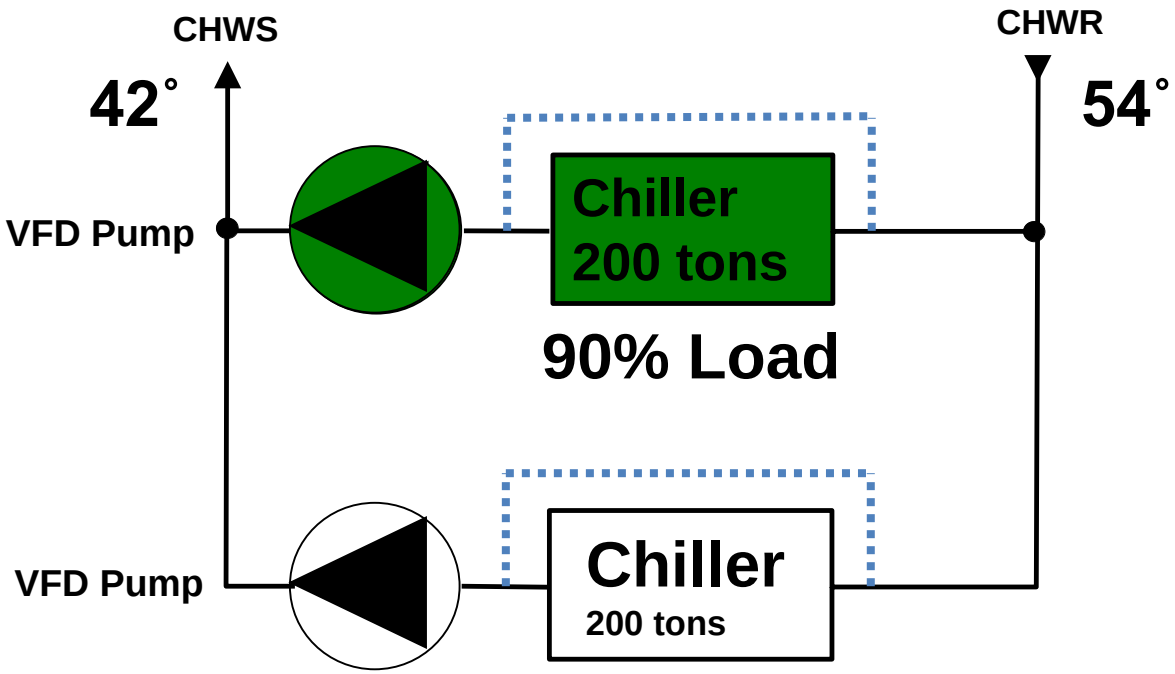
$$\frac{800\,GPM}{2} = Tons$$

$$Tons = 400$$

Typical Chilled Water System

Design: 400 Ton CHW
System @ 12˚ΔT, 800GPM

180 Ton Load (45%)



360 GPM Loop Flow

Part Load Condition (45%)

Chiller #1 Load = 90%
Chiller #2 Load = 0%
Loop Flow = 360 GPM
Chiller ΔT = 12˚F

Typical Chilled Water System

Water ΔT decreases by < 2 degrees F. = flow increases by 15%

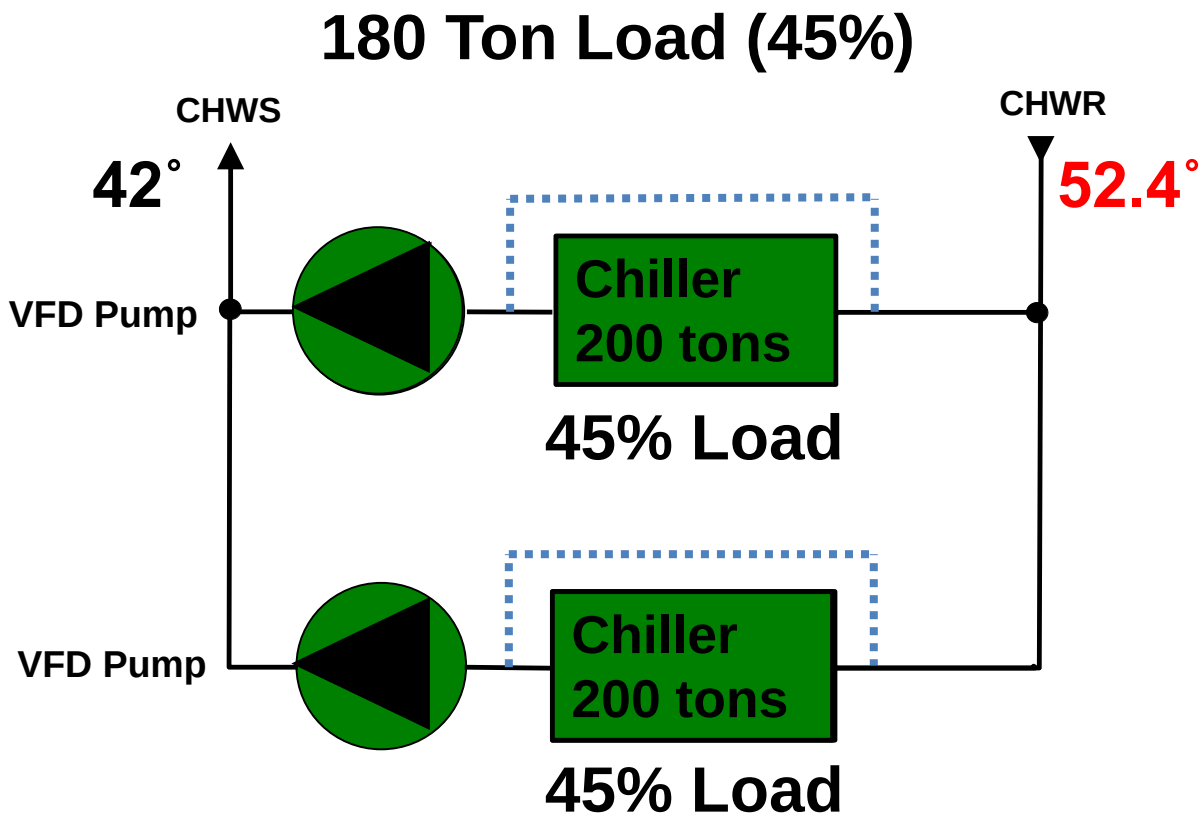
Part Load Condition (45%)

Chiller #1 Load = 45%

Chiller #2 Load = 45%

Loop Flow = 414 GPM

Chiller ΔT = 10.4˚F

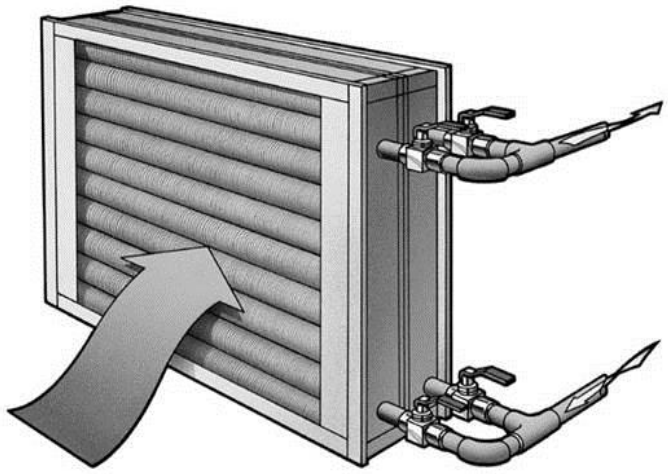


Pump Affinity Law =

Pump HP = (414/360)³ = 52% increase!

Design
Causes of Low Delta T

- **Chillers, pumps, coils, control valves and piping are oversized.**
- **Controlling the water valve using only the air sensor is insufficient.**
- **Manual balancing only addresses one flow condition.**
- **Systems infrequently run at full load causing overflow at part load.**
- **Hydronic system changes are not rebalanced.**



Hayden Library Case Study, 2010/2011

Correction CHW Low Delta T

Hayden Library Case Study

Case Study Issues

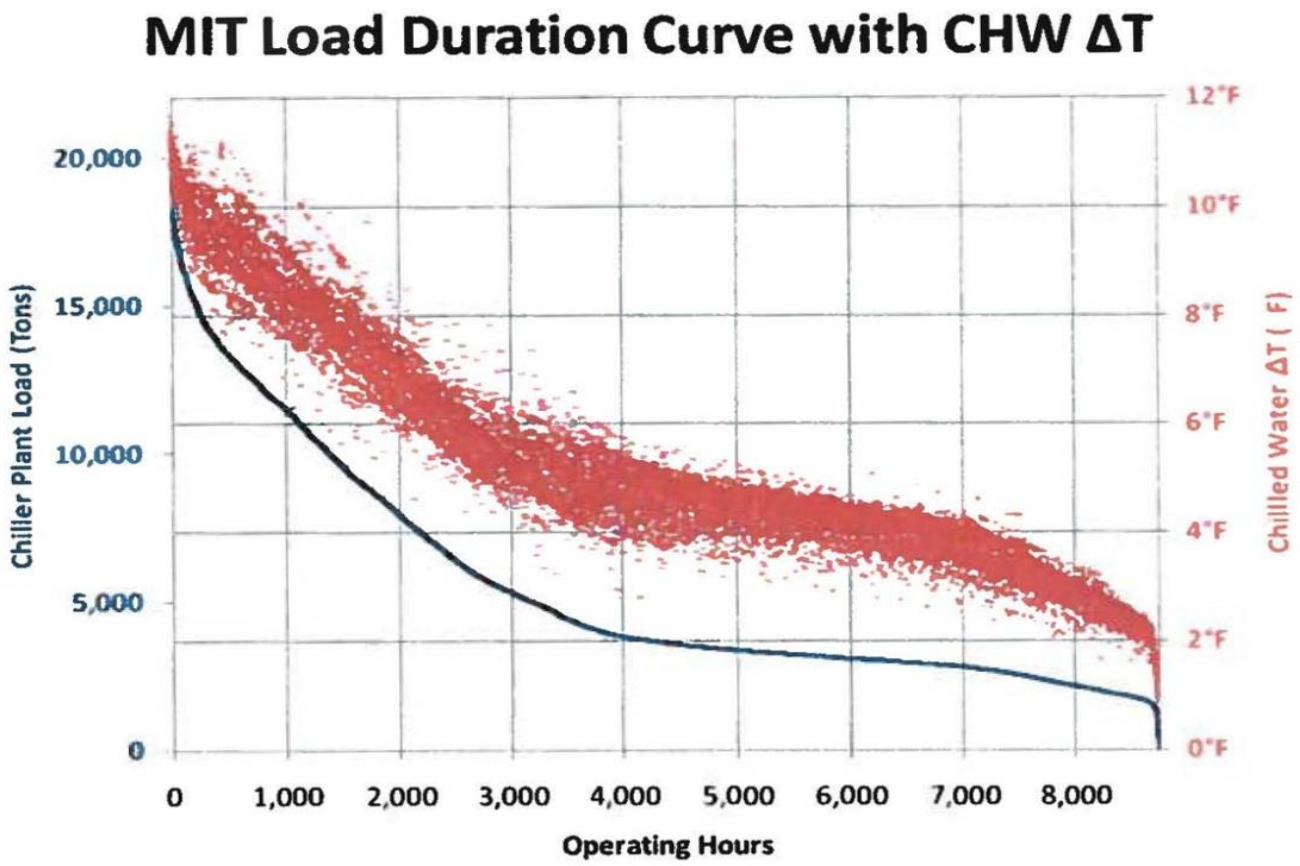
- **Coil delta T reported as 6 Degree F**
- **Over pumping**
- **Low delta T Syndrome at Chiller Plant**

6 AHU units, 153,000 sq-ft

Independent Study

MIT Chilled Water System

Peak Load 26,000 Tons



*** From 2008 Chilled Water Delta T Study**

Independent Study
MIT Savings by Eliminating
Causes of Low Delta T (30,000 Ton Plant)

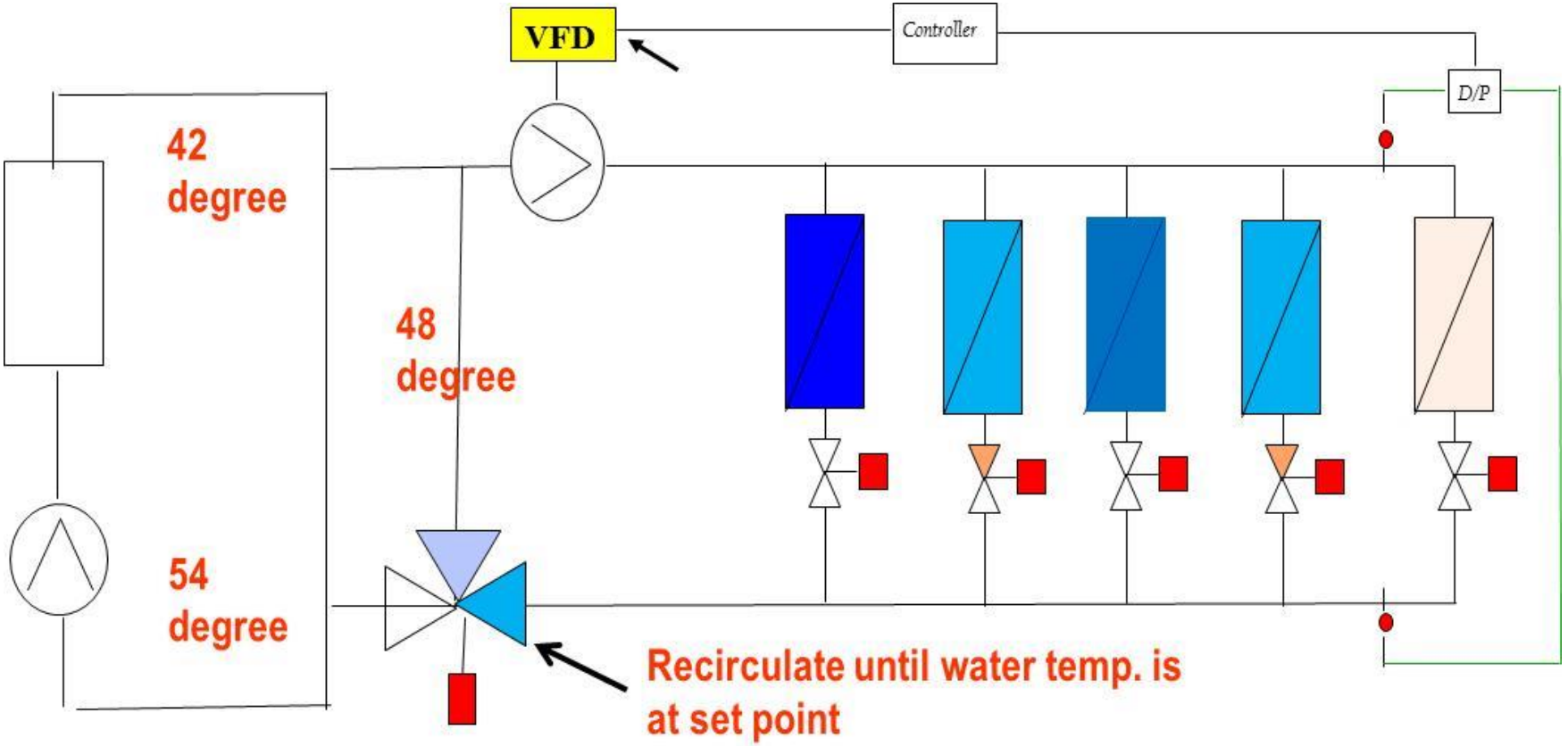
Recommend implementing chilled water delta T improvement projects across the campus.

Component	Annual Energy Savings	Annual Cost Savings
Chiller Steam	10,887 Mlbs	$181,000.00
Chiller Electric	2,576,000 kWh	$412,000.00
CHW Pump Electric	2,334,000 kWh	$373,000.00
CW Pump Electric	2,417,000 kWh	$387,000.00
CT Fan Electric	740,000 kWh	$118,000.00
TOTAL SAVINGS		$**1,471,000.00**

25% of Total

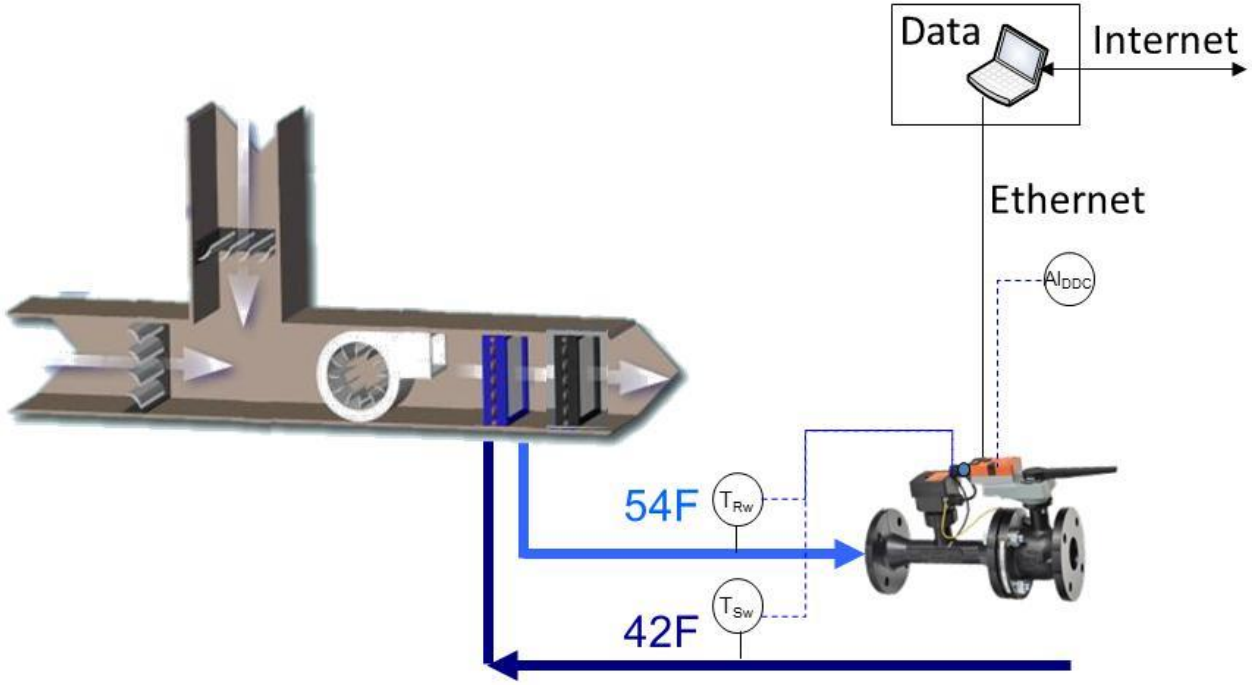
Design
Not the Solution

Deny or Choke Valve, will not allow a coil to run as designed. This application will negate proper de-humidification and comfort.



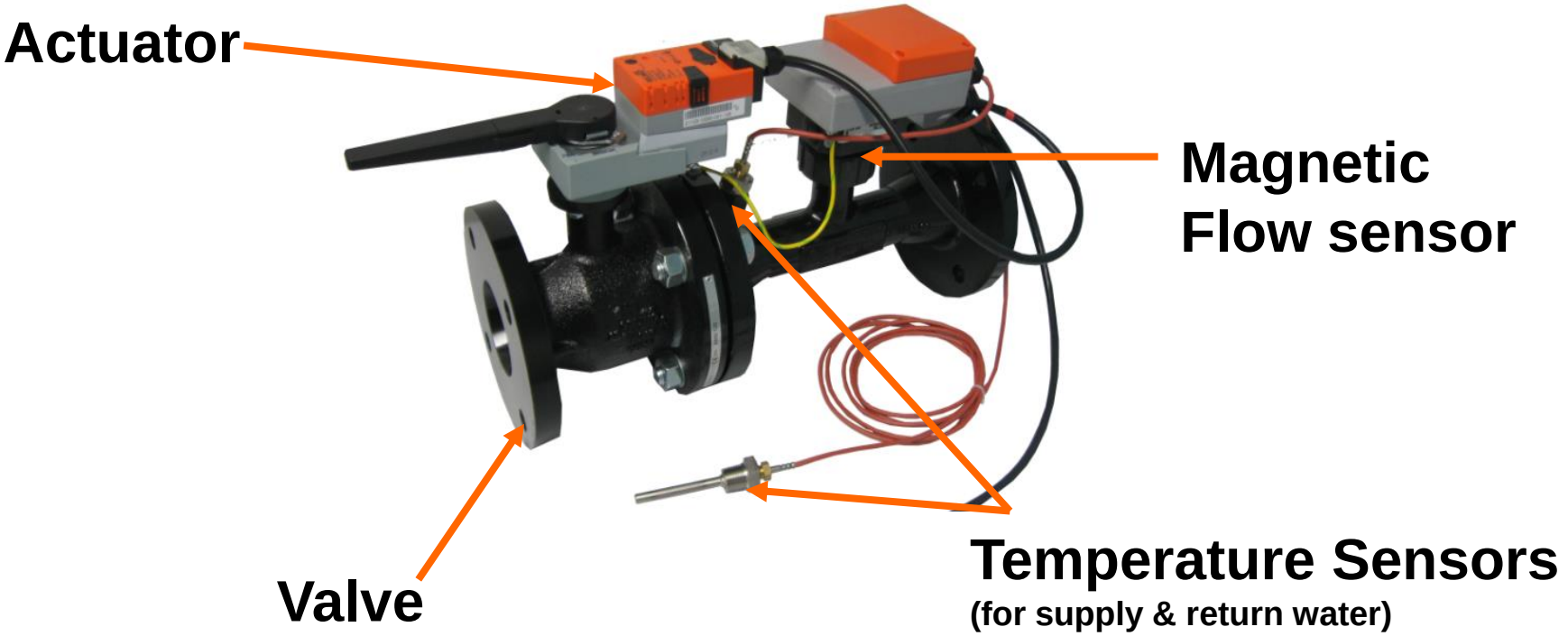
Case Study Setup

- **5 Energy Valves**
- **Chilled Water is designed to run through a coil at a designed temperature drop to supply air conditioned cooling air and to de-humidify. i.e. Water delta T=12 degrees F.**



Energy Valve
Hayden Library

The Energy Valve is a pressure independent control valve that optimizes, documents and proves water coil performance by correcting low delta T.

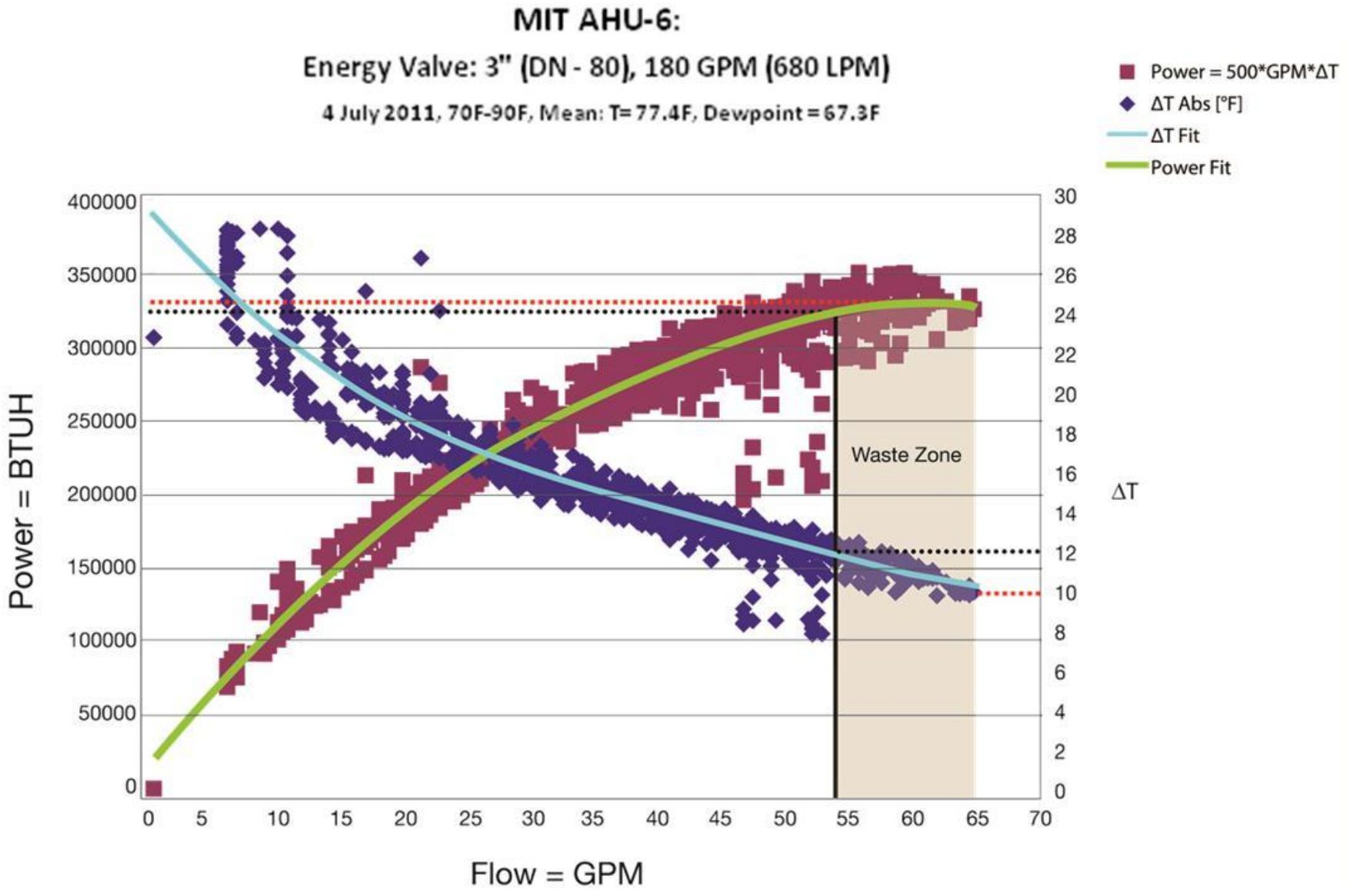


New Definitions

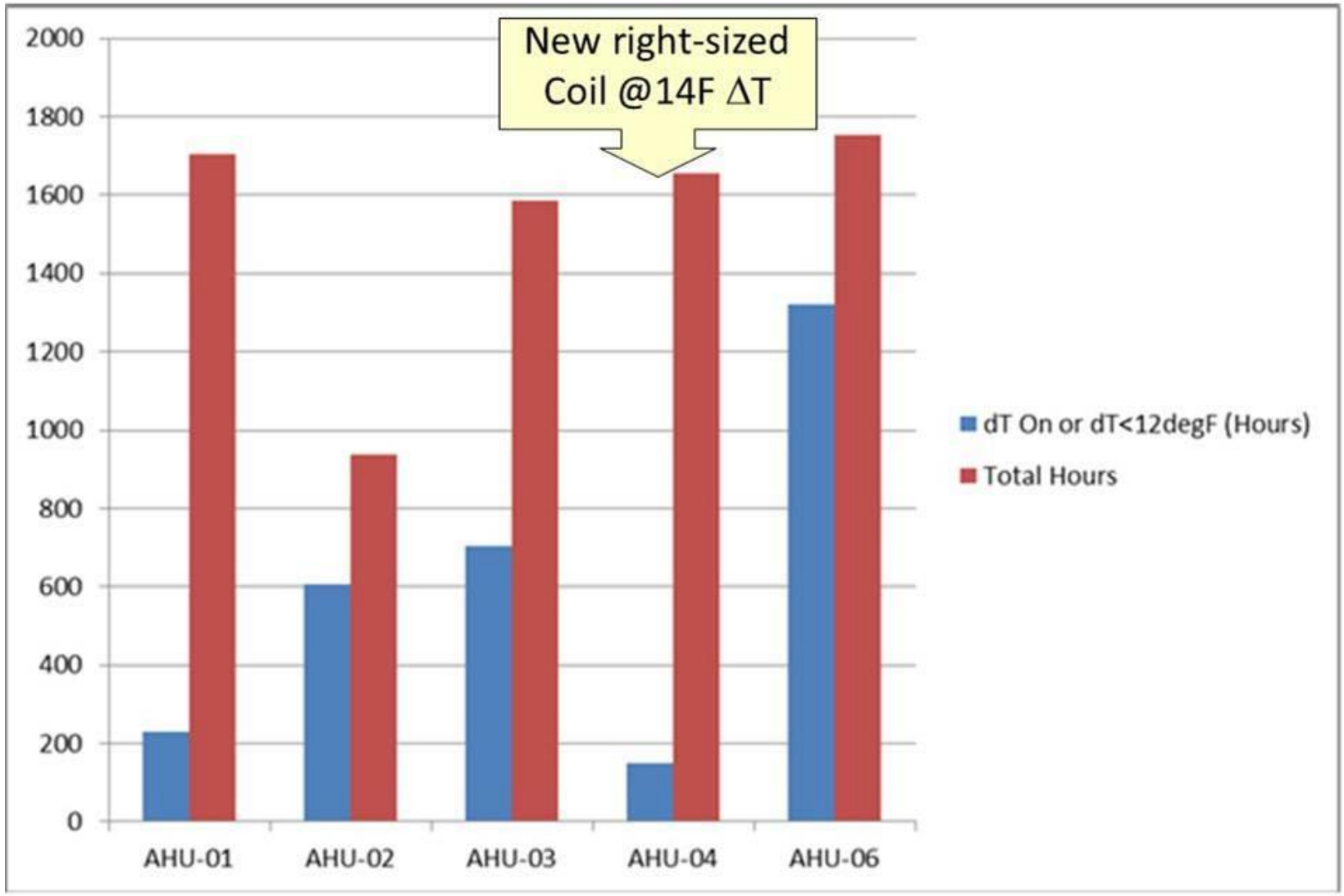
- **Power Saturation Point**
  - **Point beyond which coil cannot yield additional heat transfer regardless of increased flow.**

- **Waste Zone**
  - **Range beyond the “Power Saturation Point.”**

Power Saturation & Waste Zone



Hours Delta T Manager Active
Summer 2011



Library Whole Building Results

2011 vs. 2010 Flow

- **8/9-10/9 2010 6.15 F DT**
- **8/9-10/9 2011 12.14 F DT**
- **From whole building meters, Metering data PI archive**
- **Tonsx24/GPM= Weighted Average delta T**

6 AHU units, 153,000 sq-ft

Case Study Findings

- **The delta T limiting is especially effective on coils that display “power saturation”.**
- **Overall reduction of chilled water flow.**
- **Significant energy savings are realized in mechanical pumping energy with Delta-T Manager.**

Hayden Library Saving Calculations

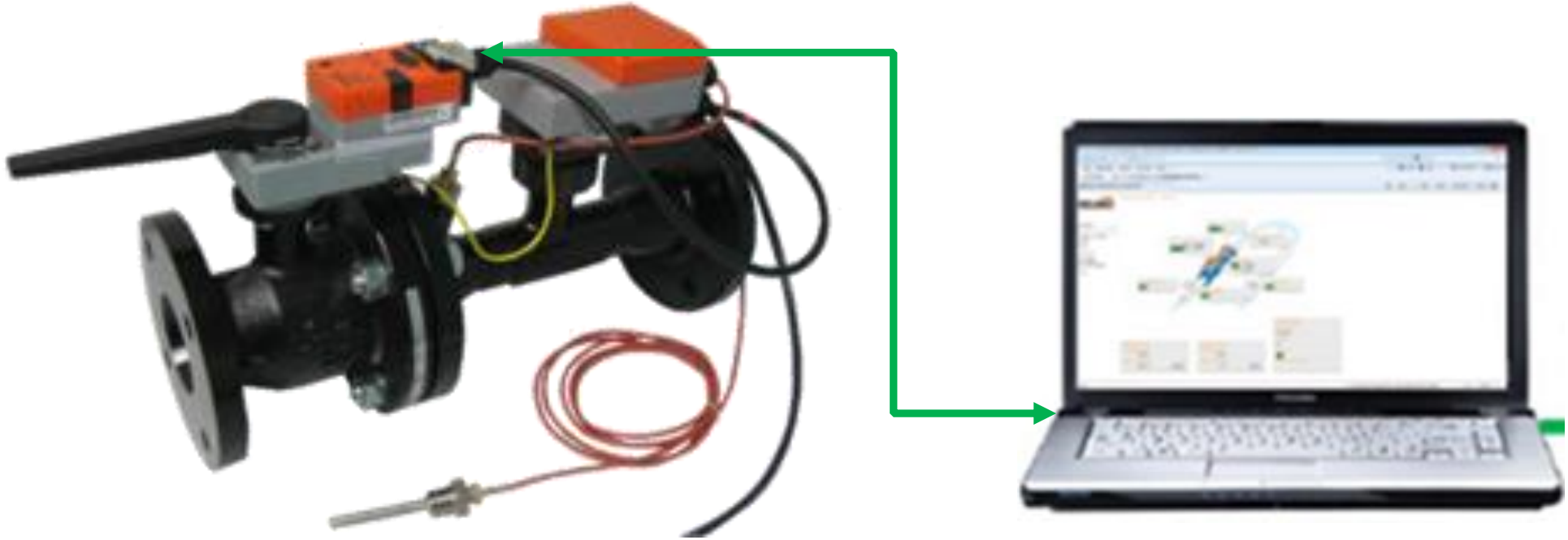
Using MIT Data increasing water delta T from 6 to 12 degrees. The potential savings for calendar year 2011 are as follows:

- **2011 had 1005 COOLING D-DAY»$12,529.00 CHW PUMP ALONE (25% of total savings).**
- **Plant savings, turning off chillers, condenser pumps and fans would equal a potential savings of $50,116.00.**

Energy Valve

Technical Summary

- Maximize coil performance
- Monitor and calculate savings at the coil level
- Documented commissioning of coil
- 13 month data archive
- Delta T management function

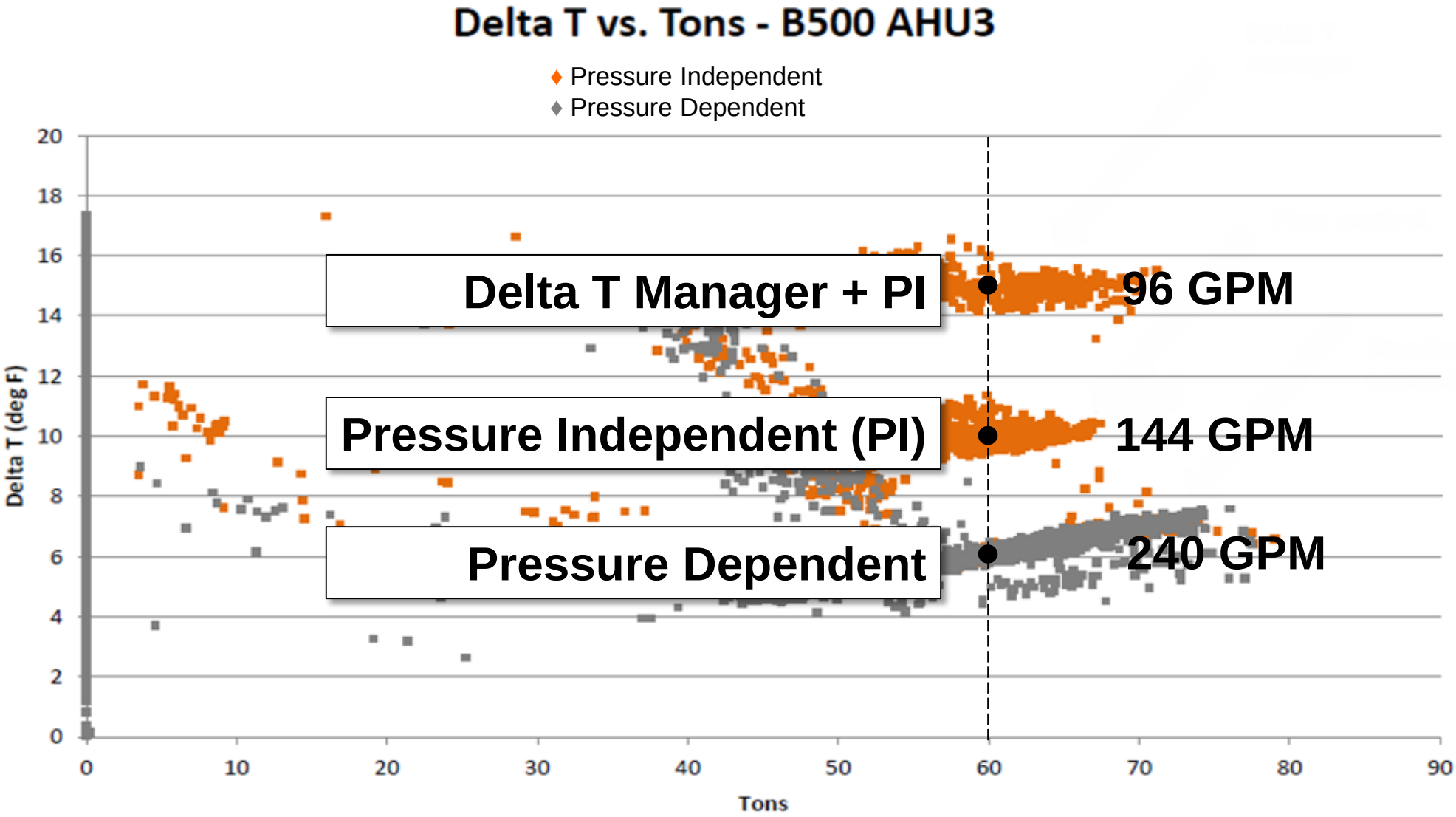


Energy Valve Operation

- **Pressure independent, integral flow meter maintains proper flow.**
- **Delta-T Manager will maintain design Coil delta-T.**
- **Delta T mitigation eliminates overflow.**
- **Flow meter and temperature sensors added no additional DDC physical points to the system.**

Pressure Independent and Delta T Manager

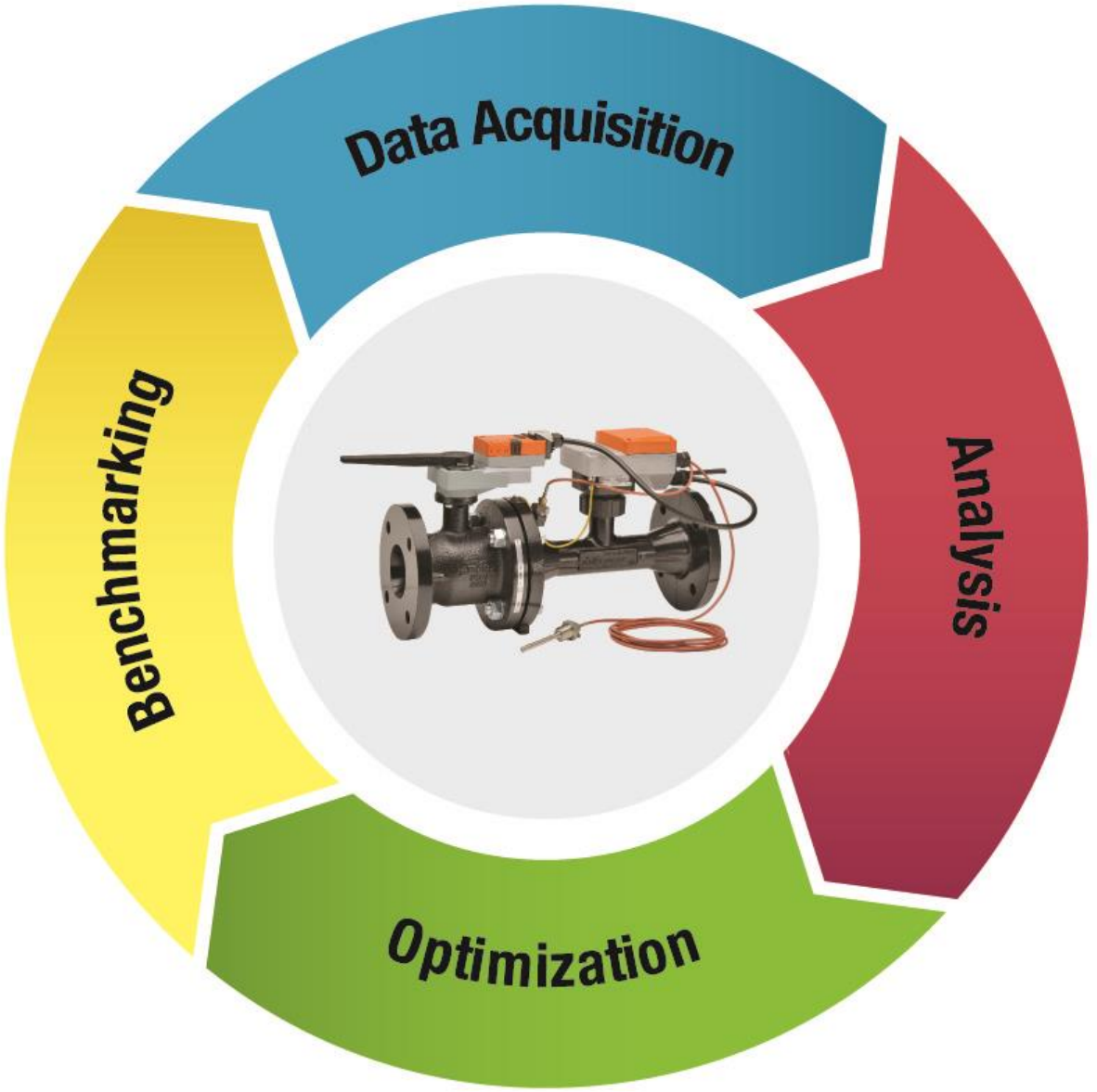
Pump Savings in Large Tech Company in NC



Knowledge is Power

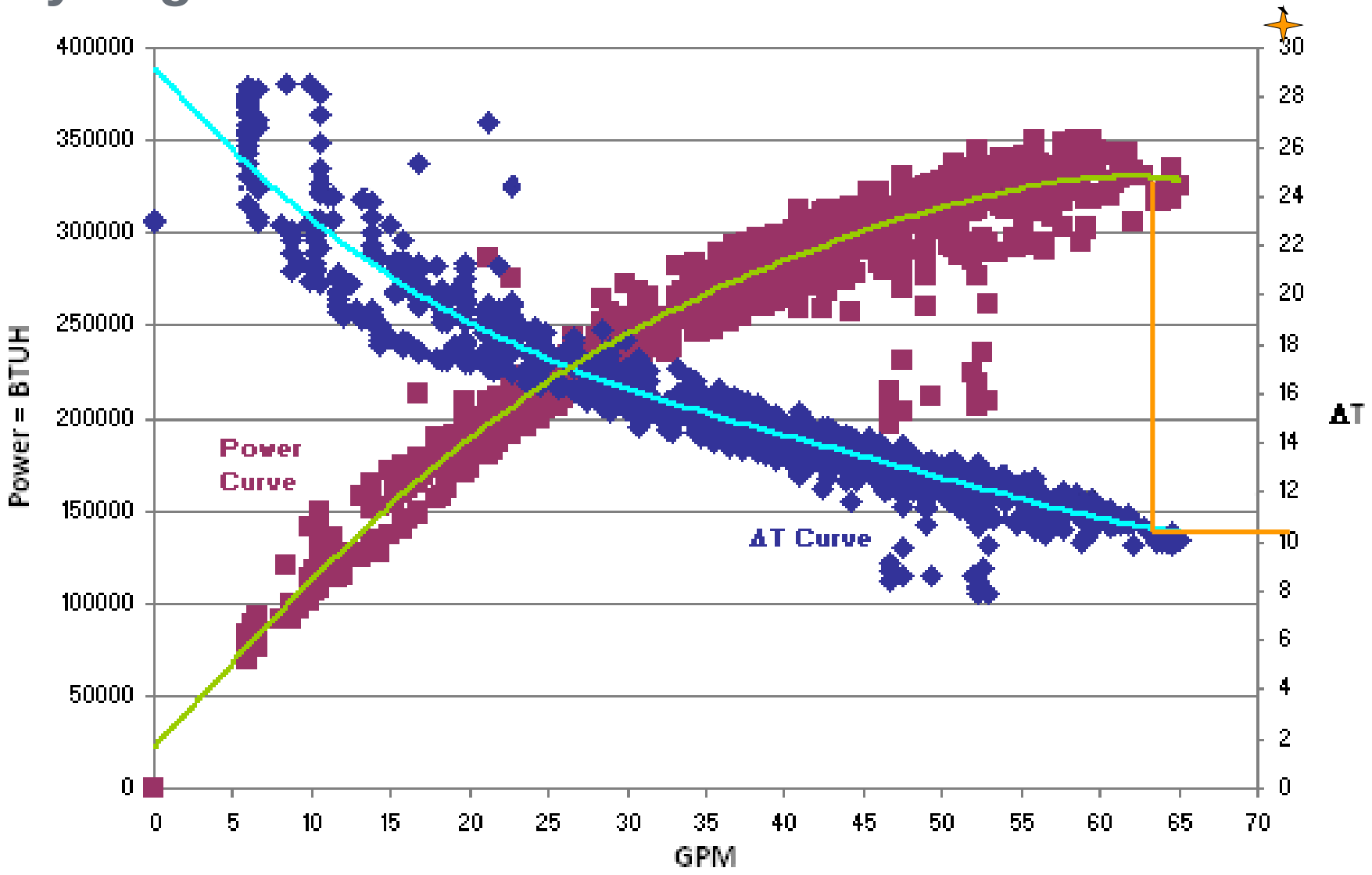
Process Order

1. Benchmarking
2. Data Acquisition
3. Analysis
4. Optimization

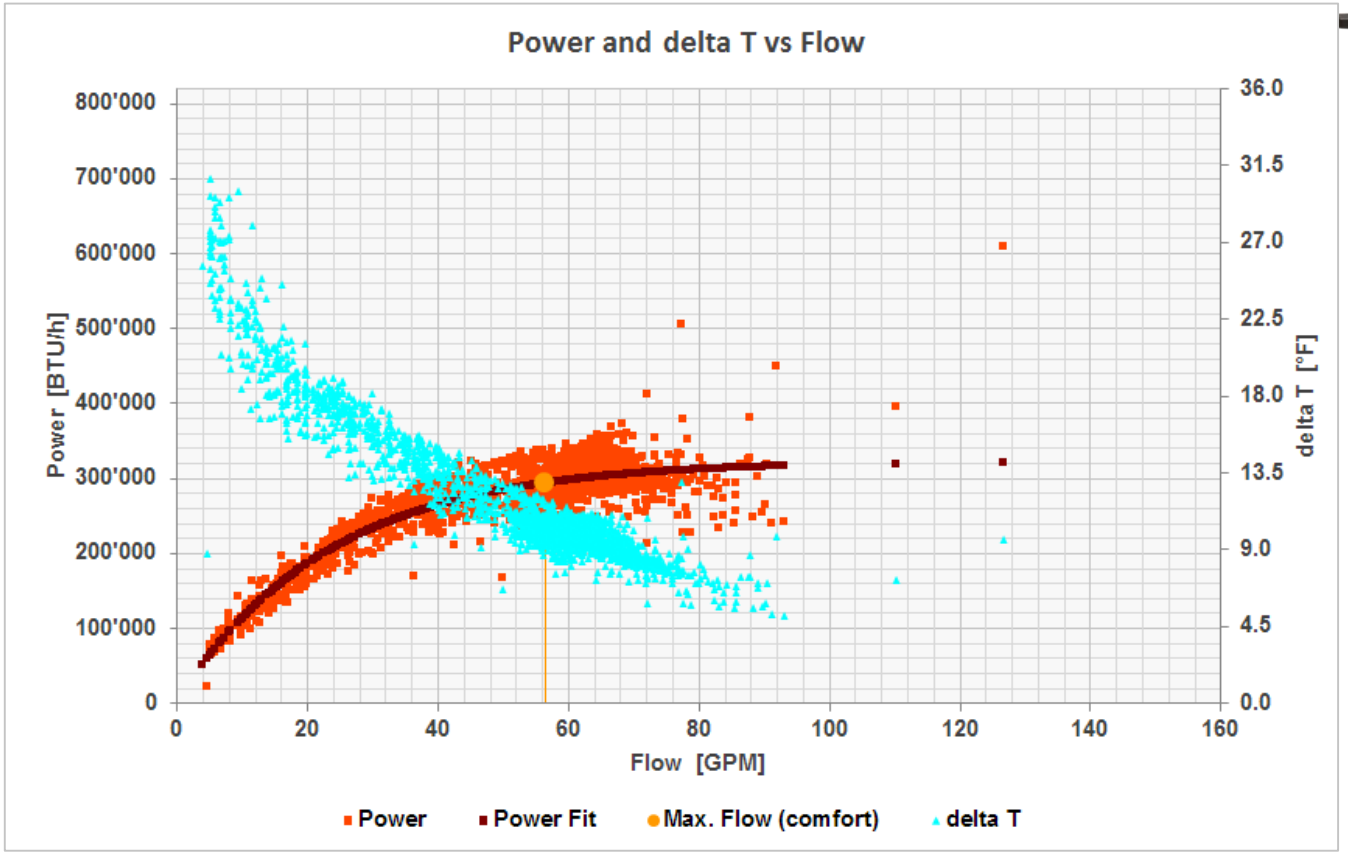


Data Analysis

Analyzing the Power Curve



Thank You


Power and delta T vs Flow
Power [BTU/h]
800'000
700'000
600'000
500'000
400'000
300'000
200'000
100'000
0
delta T [°F]
36.0
31.5
27.0
22.5
18.0
13.5
9.0
4.5
0.0
0
20
40
60
80
100
120
140
160
Flow [GPM]
Power
Power Fit
Max. Flow (comfort)
delta T


5 YEAR
WARRANTY